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SOIL AND WATER PROBLEMS AND RESEARCH NEEDS OF THE WEST

REPORT

TO

THE NATIONAL RECLAMATION ASSOCIATION

BY THE

AGRICULTURAL RESEARCH COMMITTEE

PRESENTED BY MR. HAYDEN

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FOREWORD

This document presents the report of the Agricultural Research Committee of the National Reclamation Association on soil and water problems and research needs of the West. The committee, made up of experienced men in the utilization of land and water, was appointed in 1951 and spent several months in the preparation of a report designed to bring together a summary of the progress made in soil and water research in the 17 western reclamation States. The report also contains an examination of major problems encountered in the practice of irrigation and sets forth how maximum efficiency in the use of water on irrigated farms may be attained; and it covers phases of the research program needed to demonstrate the best use of dry lands in the West not now irrigated, a large part of which is destined, because of lack of available water supplies, to remain in an arid or semiarid condition. An estimate of funds required to study these problems is included.

The need for soil and water research of this nature in the 17 Western States is convincingly demonstrated by the report. The research recommended by the report relates to ways and means to secure the best use of irrigated lands, to attain maximum crop yields, and to prevent loss of such lands after the expenditure of large sums of money has been made to bring them into production. Such research will show not only how crop production may be pushed to a high economic level, but how it may be maintained. Much may be accomplished by the expenditure of a relatively small amount of money for research to protect the investment in the reclamation of arid lands, to increase the income of the irrigation farmer, and to stabilize in the highest degree the agricultural economy of a large part of the Nation through proper irrigation practices and husbandry of the soil to which water is artificially applied.

It is urged that research on this subject look forward to an important aspect of soil and water conservation and utilization which should not be overlooked.

The recommended research program is not intended to create any new Federal agency but, on the contrary, to promote the efficiency and better integration of the activities of existing Federal and State agencies and of farmers in the West.

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SOILS AND WATER PROBLEMS AND RESEARCH NEEDS OF THE WEST

INTRODUCTION

Purpose of report

The purpose of this report is to bring together for the National Reclamation Association—

1. A summary of the progress made in the soil and water research in the 17 Western States and its present status.
2. A statement of the major problems facing our farmers in the field of soil and water research.
3. A statement of the funds needed to solve these major problems, and ways in which maximum efficiency can be achieved.

Why the National Reclamation Association is interested in soil and water research

We, of the National Reclamation Association, are intensely interested in the development, control, conservation, preservation, and utilization of our land and water resources for increased food and fiber production. We have seen the development of irrigation on millions of acres of western lands, all contributing to increased crop production. Now, only a limited number of acres remain to be brought under irrigation. However, continued demands for increasing crop production remain with us. What can be done now to meet these demands? The answer lies largely in those lands already under cultivation—lands that are not producing their maximum. In addition to our large acreage of cultivated lands, there also exists a similar challenge on the smaller acreage of lands yet to be brought under cultivation.

Making our lands produce to their fullest, presents an exciting challenge, an opportunity to benefit our western agriculture and to improve the general welfare of our Nation. Soil and water research, carried on at an adequate scale and closely integrated, can show us the way to get maximum and continued production from our lands.

Such research can help us in many other land problems. We all are aware that each year thousands of irrigated acres go bad. Salts, alkali, seepage, and other factors may be responsible. How can these lands be retained in profitable production?

We doubt if there is a single member of the National Reclamation Association who has not seen irrigation projects built, the land brought under production, a few years of good crops, and then a gradual but disastrous decline in yields. In many instances, yields have become so poor that individual farms—and in some cases, practically whole projects—have become economic failures. These failures are not just failures insofar as Government expenditures are concerned. They are failures of communities and of the lives of many, many people. In most cases, such catastrophes could have been prevented through proper use of soil and water resources.

Reasons like these focus the attention of the National Reclamation Association upon the need for soil and water research. We recognize that it is through such research that crop production may be pushed to a high level and then maintained, land kept in economic production, and the welfare of our communities and people insured.

While the National Reclamation Association is interested in all phases of agricultural production, its primary interest has been in those phases associated with irrigation and with soil and water in general. This report, therefore, deals only with soil and water research problems of the 17 Western States. Other fields of research undoubtedly need similar review and study, but in the limited time available, it was necessary to confine the scope of the committee to soil and water.

Attention is directed to the fact that needs for increased soil and water research exist in other regions of the United States and, while it is the purpose of this report to confine its attention to the 17 Western States, it intends in no way to minimize the importance of the soil and water problems elsewhere.

PROGRESS AND STATUS OF SOIL AND WATER RESEARCH IN THE WEST

Agricultural research and the Nation

Modern science and technology have transformed American agriculture in the space of a lifetime. Agriculture has made more progress in the United States in the last 75 years than in the previous 75 centuries elsewhere in the world. This period of great advancements coincides with the history of research in the United States Department of Agriculture and the State agricultural experiment stations.

To agriculture as a whole, research means an increase of 45 percent in crop yields in the last 25 years. It means a doubling of over-all efficiency in the last 50 years. In 1900, one farm worker produced enough for himself and 7 others; now, he produces enough for himself and 14 others. To the Nation, agricultural research has meant the saving of lives, assurances of ample food supplies and better nutrition for everyone.

The agencies conducting soil and water research

Before going further into the progress and status of soil and water research, it is desirable to define the agencies now conducting the research. These may be divided into two general groups: (1) the Federal through the United States Department of Agriculture, and (2) the State through the individual State agricultural experiment stations. In addition to these, there are numerous private and commercial interests conducting research.

Within the United States Department of Agriculture, three agencies are actively engaged in soils and water research. These are (1) the Bureau of Plant Industry, Soils and Agricultural Engineering, largely through its soils divisions; (2) the Research Division of the Soil Conservation Service, and (3) the Forest Service.

Accomplishments of soil and water research on irrigated lands

What are the accomplishments obtained through soil and water research on the irrigated lands of the Western States? Although soil and water research in the irrigated West has been conducted on a

much smaller scale and with less funds than has some of the Nation's other agricultural research activities, nevertheless it has given good returns.

Below are listed some of the major advances made during the past 40 years.

Development of profitable systems of crop rotations and crop sequences.—The rotation of crops on irrigated lands is accepted practice by most farmers today. At the turn of the century, single-crop systems were the rule. Rotation systems for irrigated lands were developed on the older irrigation experiment stations.

Methods of irrigation.—Irrigation practices now followed throughout the West were developed largely through research. Many problems remain to be solved.

Reduction of erosion.—Running water causes soil erosion. Ways and means of minimizing water erosion have been worked out. Great progress also has been made in controlling wind erosion on our sandy soils.

Increasing the efficiency of water use.—Some steps have been developed for improving efficiency of water use. These include practices such as lining of canals, gaging the length of irrigation run to the infiltration rate and water-holding capacity of the soil, and limiting the time of irrigation.

There is, however, another factor relating to efficient water use that has received relatively little attention. This factor is one of supplying water in accordance with the water need of the crop at a particular stage of growth. At Scotts Bluff, Nebr., in 1950, for example, three irrigations on corn placed at and near tasseling produced as high yields as eight irrigations scattered over the season. Equally striking results with corn and other crops have been obtained at Prosser, Wash., and Logan, Utah. Results also show that with different crops, the soil-moisture content of the soil must be maintained at different levels. That which is optimum for one crop is not optimum for another.

Much still remains to be done in improving the efficiency of water use.

Improvement of soil fertility.—Nitrogen and phosphorus have been found to be the most limiting plant-nutrient elements in the West. Additions of nitrogen to the soil, either in the form of commercial fertilizer, manure, or legumes is essential for the production of nonleguminous crops. Phosphorus is needed in certain localities but not universally. Crops like alfalfa need more phosphorus than certain other crops. Minor elements like zinc and iron are deficient on some soils.

Here, again, only the surface has been scratched. Placement, rates, and kinds of fertilizers need to be studied at many locations in the West. Improved soil tests must be developed.

Adjusting plant populations to the producing capacity of the soil.—Too thin plantings and too wide spacing of rows have been found to limit yields of otherwise well-managed row crops in the West. Plant population must be adjusted to the producing capacity of the soil, the amount of fertilizer used, and the available soil moisture. The principles have been discovered. Much needs to be done to broaden their applications.

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Increased production of grass and legume seed.—Nitrogen use and drilling in rows has revolutionized grass-seed production. Alfalfa-seed production still lags. Much research is required before alfalfa-seed production can reach desired levels.

Improved management has multiplied pasture yields.—Early phases of mountain-meadow research show that nitrogen fertilizer applied on well-drained meadows increases hay yields fourfold and greatly improves the quality and feeding value of the hay. Renovation, rotation, and fertilization of irrigated pastures markedly increase production.

Adequate pastures still remain a major problem in many areas of the West.

Correct tillage methods improve yields.—Fall plowing has greatly improved yields of sugar beets and other crops in many sections. For the most part, however, tillage research has been neglected. There is needed research on the advantages of deep-plowing, chiseling, and other tillage practices.

Selection of adapted crops and varieties.—While not strictly a soil and water problem, selection of adapted crops and varieties is absolutely necessary for a successful agriculture in any area. Fair progress has been made, but most varieties used in the West are introduced from nonirrigated areas. Can production be markedly increased if varieties were developed specifically for irrigated areas?

Research is showing that varieties ranking highest under certain soil and water conditions are not best under others. This means that variety testing should be done at more than one level of soil and water management.

Combination of factors for maximum production.—Research has continually shown that all major factors of soil management and crop production must be brought together in exactly the right combination if maximum yields are to be realized. For water to be used most efficiently, the soil must be well fertilized, good crop varieties planted, and adequate plant populations used. Even then, overlooking any other limiting factor may result in low yields.

Much more must be done in studying combinations of factors.

Control of salt balance.—It is general knowledge that the use of saline irrigation water causes salts to accumulate in the soil. These salts must be removed or the land will go bad. Artificial drainage may be imperative to keep certain lands in production. The trend in salt accumulation for any area must be known. A balance known as "salt balance," must exist between salt input from the irrigation water and salt output through the drainage water. If salt input exceeds output, then the land will become unproductive. Research results now make it possible to adequately determine salt balance for many areas, thus indicating whether steps must be taken to remedy the situation in order to keep land in production.

Quality of irrigation water.—Research has been conducted to determine the quality of water and its suitability for irrigation on different kinds of soil. For example, it has been found that irrigation waters can contain higher amounts of salts when used on sandy soils than when used on clay soils.

Chemical analyses of waters permit fairly sound evaluation as to its desirability for irrigation.

Reclamation of alkali soils.—The sodium held by the clay fractions of soils may result in alkali conditions. A high sodium irrigation water may bring about or intensify the alkali problem. Satisfactory progress has been made in determining the causes of alkali soils. Limited progress has been made in developing methods for their reclamation.

Development and improvement of laboratory and field measuring techniques.—Equipment and procedures have been developed for measuring the tension of moisture in the soil, determining field and laboratory infiltration rates of water into the soil, determining porosity, following the movement of underground waters, measuring irrigation waters, and many others.

Much remains to be done before some of these techniques can be used easily and practically in the field.

Research history on the older irrigated areas

Many of the accomplishments listed above resulted from research on the older irrigated areas. It is the purpose here to give a background and brief history of this research and how it was undertaken.

Federal irrigation research in the West was started on a modest scale with the establishment of a number of Federal field stations in about 1910, following the enactment of the Federal reclamation law of 1902. Major emphasis was placed on crop-rotation studies in which various sequences of crops were compared under different manurial and management practices.

The accomplishments of the Umatilla station, Hermiston, Oreg., should be noted as typical of the progress made by the older stations.

In addition to crop-rotation studies, early lines of investigation included—

1. Methods of irrigation.
2. The conservation of water.
3. The reduction of erosion.
4. Ways of improving fertility and management practices.

The early experiment stations solved many of the most serious problems which faced them at the time of their initiation. Their history, however, follows a common and not too encouraging pattern. Research work usually was at at high level and intensity for a few years. Then, due to either decreasing dollar values or actually decreased appropriations, the stations were no longer able to maintain their original tempo of research. Research stations more and more were forced to conduct their lands as farm lands. Research quality and quantity decreased due to lack of funds.

More recently, some funds have been restored. New strides have been made in determining fertility requirements, selection of adapted crops and crop varieties, determining best plant spacings, in improving irrigation practices, and in bringing these and other soil- and crop-management factors together for maximum production and more efficient use of our soil and water resources.

Almost all of the State experiment stations can point to striking increases in yield through research on their older irrigated areas. One example, however, is given here from experimental work conducted cooperatively between the United States Department of Agriculture and the Utah Agricultural Experiment Station. The work

reported involves research in 1945, 1946, and 1947. In 1946, experiments were conducted in this area in which the factors of soil moisture, fertility, and spacing of plants were combined in one factorial experiment. This, then, made it possible to find out how three factors, each independently capable of materially affecting yield, could be put together in a combination which would result not only in highest sugar-beet yields but in highest economy and efficiency of production. Yields up to 26 tons per acre were obtained in this experiment. Since 1946, additional experiments have been conducted and up to 34 tons per acre have been obtained. In this area, the average yield of sugar beets is around 13 tons per acre. A very important consideration in sugar-beet production is the fact that it takes approximately 10 tons of beets to pay for the cost of production of a crop. A 13-ton yield gives about a 3-ton profit. A 16-ton yield would practically double the profit to the farmers. The economic importance of such increases is obvious.

Research history on new irrigated lands

With the formulation of the development farm idea, land and water are made available for research agencies in areas not yet under irrigation. At present, research is being conducted on development farms in new areas in the Columbia Basin, North and South Dakota, and Nebraska. The Columbia Basin will be cited here as a more or less typical example.

Soil and water research is clearing the way to a profitable and stable agriculture for the settlers on the new lands of the Columbia Basin. The story of the Columbia Basin is similar to all new irrigation projects, namely, new land, new water, and new and often inexperienced irrigation farmers who have very little free capital. The unique research approach in the basin has been to anticipate and solve before the land is settled the many soil and water problems. As a result of research, the new settler also will know which crops and varieties are best adapted to his land, and how best to control plant diseases and insects.

The Columbia Basin approach is the result of foresight and imagination during the planning and development of the project. Representatives of the Washington Agricultural Experiment Station, the Agricultural Research Administration of the United States Department of Agriculture, and the Bureau of Reclamation all contributed to the planning and execution of this program. Facilities in both land and laboratories were made available, predevelopment water supplies were provided, and a scientific staff was recruited.

Many of the problems which will confront the new farmer have been solved. Others, not previously anticipated, have arisen. Some of these, such as an unexpected deficiency in zinc in the soils, would have meant certain crop failure to the settlers.

Unusually high crop yields have been produced in the basin. Some of the maximum yields are given below. These yields were produced only when the best-adapted crops were combined with correct irrigation and the use of the right kinds and amounts of fertilizer. It is believed that these yields are within the reach of the new settler if he follows recommended practices developed through research. Such yields will insure the success of the Columbia Basin project.

Crop	Yield per acre	Crop	Yield per acre
Alfalfa	8.7 tons.	Grain sorghum	165.5 bushels.
Barley	85.3 bushels.	Field corn	173 bushels.
Oats	113.7 bushels.	Sugar beets	37.1 tons.
Winter wheat	72.8 bushels.	Potatoes	16.3 tons (U. S. No. 1).
Spring wheat	58.2 bushels.	Field beans	4,211 pounds.

Research on salinity problems

Reclaiming saline and alkali lands and keeping lands from developing salt and alkali problems are of high priority in our western irrigated agriculture. The establishment of the United States Salinity Laboratory at Riverside, Calif., in 1937, has permitted great strides to be made over the entire West. This laboratory, along with the individual State experiment stations, has conducted considerable research on the effects of salts and alkali on soils and crops, ways for correcting salt and alkali conditions, and the effects of quality of irrigation waters upon soils and crops. From the results of this work, it is now often possible to logically plan the reclamation of saline and alkali lands.

Results of salinity research now are made available to all new projects coming under irrigation. Research data collected during the past few years are being used every day in considering soils and lands for new irrigation projects and in reclaiming lands that have either gone out of irrigation or where their productivity is threatened.

A large number of areas in the West still need research to determine the best methods of reclaiming them. Information on land drainage particularly is lacking, and drainage often is necessary to reclaim saline and alkali lands. Each soil and each source of irrigation water presents a problem of its own. Thus, intensified research is needed on individual problem areas.

Dry-land research and its accomplishments

The production of crops in the dry-land area of the 17 Western States represents a major industry, and is vitally important to the economy of these States and to the Nation as a whole. While the magnitude of most crop yields is not as phenomenal nor is the yield potential due to best practices as great as it is in the adjacent irrigated areas, there is a wide expanse of nonirrigated lands in the 17 Western States on which soil and water research has tremendous opportunity for greatly increasing crop production. The importance and magnitude of this agricultural region is best exemplified by the fact that it embraces an area of approximately 288,000,000 acres, some two-thirds of which are tillable, agricultural lands of potentially great productive capacity and the remainder of which are grazing or range lands. Soon after the turn of the century, the United States Department of Agriculture, through the Division of Dry Land Agriculture and the State experiment stations, commenced study on some of the soil and water problems of the dry-land areas. Field stations were established throughout various regions of the 17 Western States. The initial problems were many and diverse. The major activities of the early stations were confined primarily to the solution of practical problems, many of which were only remotely related to the basic and fundamental research on the management of soils and water in the dry-land regions.

In this program first emphasis was put on production potential of various crops under dry-land conditions. Such problems as adaptability of crops, with special emphasis on crop varieties adapted to drought, heat, short growing seasons, as well as insects and plant parasites and other menaces were some of the more important things studied. Much effort was also put forth on crop rotations and tillage methods under which maximum production could be realized. The prevention of wind erosion was one of the first and ever-present problems facing the technicians and the farmer in the dry land regions. In addition to considerable progress on these factors, one of the main contributions of the dry-land stations was the development of summer fallow which sacrifices one crop to store moisture for the next. In many areas, this has not only increased the yield of the crops, but has reduced considerably the number of years of crop failures.

The research work in dry-land agriculture has shown a considerable decline in the organic matter content of the dry-land soils. An extensive regional study of determining the total nitrogen and organic changes in the soils as the result of 28–40 years of continuous small-grain culture, shows that the loss has been 25 to 50 percent of the original organic matter content of many of the dry-land soils. None of the farming systems developed today have been able to maintain the organic matter in its original state. In general, associated with the loss in organic matter is the loss of productivity, water infiltration and permeability, consequently, an increase in the wind and water erosiveness of our soils. While much has been done in stabilizing dry-land agriculture of the West through soil and water research, many problems have been pointed up which are vital to the continued production of lands in this region.

Past budgets for soil and water research

A brief view has now been obtained of the progress and status of soil and water research in the West. Of interest to the association will be the amount of funds available for conducting this research. In table 1 the total amount of soil and water funds available to the State agricultural experiment stations and to the United States Department of Agriculture research agencies from 1940 to 1949 in the 17 Western States are given.

TABLE 1.—*Funds available for soil and water research on agricultural lands, 1940–49*

Year	State experiment stations[1]	Total for—		Year	State experiment stations[1]	Total for—	
		Federal	State and Federal			Federal	State and Federal
1940	$456,000			1945	$622,000	$1,072,000	$1,694,000
1941	463,000	$1,083,000	$1,546,000	1946	739,000	1,157,000	1,896,000
1942	481,000	1,092,000	1,573,000	1947	903,000	1,285,000	2,188,000
1943	510,000	1,077,000	1,587,000	1948	1,163,000	1,384,000	2,547,000
1944	563,000	1,082,000	1,645,000	1949	1,311,000	1,699,000	3,010,000

[1] Based on an estimate that soil and water research receives 7 percent of the total research money available to State experiment stations.

A total of $1,546,000 was available for State and Federal soil and water research in 1941. By 1949, the total funds had risen to $3,010,000. However, the research dollar is like the grocery dollar,

it wouldn't buy as much in 1949 as it did in 1941. Actually, the 1941 funds bought more research than the 1949 funds. There was a decrease in research purchased even though the budget was about doubled.

It should be noted also that a large portion of the increase in funds has come about through increased appropriations to the State experiment stations by the State legislatures. Only a relatively small increase has come from federally appropriated funds. Most of the increases in funds have gone into new work in new locations. This has resulted in a decrease in funds in areas where work was already started. As a result, research at the older locations where research is still greatly needed, in many instances, has come to a standstill.

MAJOR PROBLEMS AND RESEARCH NEEDED, INCLUDING A PROPOSED BUDGET

The directors of the State agricultural experiment stations of the 17 Western States were asked to prepare a short report on the major soil and water problems in their respective States. This report was to include (1) a survey of some of the work being done, and (2) an estimate of funds under present dollar values that would be required to attack adequately the soil and water problems which could not be investigated under their present budget. Several of the directors prepared rather complete reports. Others, however, reported on only a few items and some prepared no report at all.

There are a considerable number of soil and water problems which seem to be common to most of the States. A short description of each major problem is given below.

Soil, water, and plant factors that limit production

These factors include water requirements of common crops grown under various soil and cultural conditions, times and methods of irrigation, how much water to apply, the amounts and kinds of fertilizers needed, when and how fertilizers and manure should be applied, crop rotations and crop sequences, tillage, plant populations, and many others.

Often interrelationships exist between two or more of these factors. For example, plant population, fertilizer application, and tillage may influence the amount of water required to produce a crop. The interrelationships may be very complex and difficult to determine. But the correct balancing of one factor with another, or the combination of several factors in the best possible combinations, results in maximum and most efficient use of soil and water.

Some of the more important individual factors and problems needing intensified study are listed below:

The determination of water requirements of important crops and at different stages of growth.—The relationship between soil-moisture tension and the yield of crops and the depth of rooting of the crop in the soil zone in which water supply is most critical needs to be determined.

The development and improvement of methods for determining and measuring water application efficiencies and water requirements.—At present, these methods are tedious and expensive. Lack of adequate methods to date have limited research in this field.

The development of improved and more economical irrigation methods.—Much has been done along this line, but much more must be done before extensive waste now occurring can be prevented. Irrigation methods as referred to here include the surface methods, such as flooding and furrow, as well as sprinkler and subirrigation.

Improvement of farm-irrigation systems, including small irrigation structures for best control of water.—This will include research on such things as lining of ditches, concrete-pipe systems, and effective structures.

The determination of fertility needs of irrigated soils.—Research has shown that nitrogen and phosphorus are the most commonly needed nutrient elements for increased crop production in the West. Very little information exists, however, on how much nitrogen is needed by various crops growing under different cropping systems, or how much phosphorus is needed. There is an urgent need for information on the best kinds of phosphate to apply, and when and how it should be applied.

Certain minor nutrient elements, such as zinc and iron, have been found deficient on certain soils. More study is required to locate deficient areas and to determine how best to correct them.

Relatively large amounts of potassium are used in some sections of the West. There is little evidence to indicate that potassium is needed. More research is required to determine if potassium is of any real benefit, either in crop yield or crop quality.

Estimation of fertility levels of soils.—At the present time there are no absolutely dependable laboratory methods for determining accurately the kind and amount of fertilizer that is needed. This is an extremely important problem to both the entire irrigated and dry land regions of the Western States. The regional laboratory, to be discussed later, would provide facilities for studies of this type.

Determination of the interrelation between nutrient supply and moisture level of the soil.—Current investigations show a striking interaction between the nutrient supply and moisture level in the soil. Research has shown that increasing moisture levels to optimum may not materially increase yields unless the fertility level of the soil also is increased. For instance, at Hermiston, Oreg., increasing the moisture did not increase the yield of corn over the check plots when fertility treatment was similar to regular practices; but when the fertility level was increased along with increased moisture levels, corn yields were increased from 50-some bushels per acre to 140 bushels per acre. More research is needed to determine this interrelation under different climatic and soil variations.

Improvement of soil aeration, soil permeability, and infiltration.—Many of the soils of the West are poorly aerated. Without proper aeration, low yields result. Lack of aeration appears associated with certain heavy soils and may result from soil compaction with farm implements, poor cropping practices, lack of organic matter, and other factors. The causes of poor aeration need to be more accurately determined, and ways and means developed for improving aeration. Aeration control to date has been almost completely ignored, but still it is a tremendously important factor in crop production on irrigated lands.

Waterlogging of soils presents a serious problem. This may result from poor drainage, high water tables, or from the presence of a

compacted zone or impervious layers. Ways of improving this situation are needed.

Some soils have extremely low infiltration rates. Presence of alkali or high silt and clay contents may result in the inability to get water into the root zone of the plants. On extremely sandy soils, the reverse is true. It is difficult to get water over the fields and, at the same time, prevent loss from percolation. What can be done to improve these conditions?

Deterioration of irrigated lands

There are a number of causes of deterioration of irrigated lands in the West. The principal ones are as follows:

The accumulation of salt and alkali.—In the decade from 1929 to 1939, over a million acres of land in the 17 Western States were abandoned due to excess salts and alkali. These were not the only losses associated with the increased salt and alkali content of the irrigated areas; losses from reduction in yield or in quality of crops on many other lands containing some salts but not enough to throw them out of production have occurred. It is estimated that in many cases such losses amounted to 15 to 25 percent of the total yields. Although many of the soils of the irrigated areas are nonsaline and are in little danger from salt injury, the accumulation of salt is a continuing hazard for crop production on nearly all of the 20,000,000 acres of land in the West.

It is expected that the salt danger will increase rather than diminish, since the trend of irrigation agriculture is in the direction of utilizing all of the available water, including the drainage water, and the return flow from older irrigated areas. These waters contain increasing amounts of salt which are picked up in the ground water and returned to the main stream. The down-stream waters are, therefore, less desirable for use in irrigation. It is imperative to all of the West and to the Nation as a whole that research on salinity and alkali be strengthened and ways and means be found to reclaim the saline and alkali soils as well as finding ways of preventing good lands from going bad.

Drainage.—It is difficult to disassociate the drainage problem from that of the saline and alkali problem. In most cases, the saline and alkali problems are connected with drainage difficulties. However, this is not always the case. In many of our irrigated lands of the West the underground drainage is not sufficient to provide free flow of water and the build-up of water table results. This almost universally causes an increase in the salt and alkali content of the soil. As indicated above, an increase in the salt and alkali content is responsible for many of the lands going out of production, and a resultant decrease in the yields of many other lands. Drainage is an essential part of every successful irrigation project. Ground waters invariably accumulate in the lower areas of nearly all irrigation projects, except in a few places where natural drainage into deep rivers, channels, or tributaries is adequate. At present drainage is one of the most difficult problems to solve in many of the irrigated areas.

The removal of water from soil is dependent upon specific characteristics of the soil, including its stratification and permeability. The most effective method of drainage depends upon many factors. Pumping from wells has been one of the most effective and economical means in areas where conditions are such that satisfactory wells can be ob-

tained. Much information is needed on methods of installing tile, especially with respect to depth and distance between tiles. Basic research is needed on the principles of waterflow through soils, the extent of areas needing drainage and the depth to the water table on these areas, new and improved equipment and facilities for conducting drainage research, and the cost and effectiveness of the various methods for drainage.

Loss of fertility.—There is hardly an irrigated region of the West in which there has not been a loss of fertility in many parts of the area. This loss in fertility is accompanied by drastic reduction in crop growth and, in many cases, results in an unprofitable irrigation agriculture. In most any irrigation project, there are farmers who are getting relatively good yields, while a large number of farms are receiving submarginal yields. In many cases experiment stations have found rotations and fertility practices which do maintain these yields. The question immediately arises as to whether crops on the submarginal farms could produce as well as the better farms. In many cases, the answers are not available as to whether or not the better practices can be transferred to the other farms. This is especially difficult in fertility problems since past history and cropping systems are vitally important.

Loss of good physical conditions.—The good physical condition of the soils of the irrigated region is a necessity if high production is to be assured. Our irrigated area is based on the artificial application of water to soils. There must, therefore, be a good physical condition of the soil allowing for rapid infiltration of water into and through the soil. In many of the irrigated areas of the West, such problems as surface crusting, soil-structure deterioration. forming of hardpans, and the accumulation of salt and alkali—all add to the deterioration of the physical properties of the soil. In some areas there has been a loss in organic matter. Research is urgently needed on methods of improving the soil physical conditions where it has deteriorated and on ways of maintaining a good physical condition where it is satisfactory at the present time. Such information should involve work on organic matter, tillage practices, and soil amendments, plow sole formations, the effect of deep-rooted grasses and legumes, and the importance of varying water quality.

Determination of suitability of soils for irrigation

The determination of suitability of lands for irrigation is one of the major problems in relation to bringing new lands under irrigation in the West.—While there are a large number of factors that will affect the suitability of land for irrigation, the soil and its characteristics are among the most important ones. There is in the West much more land available for irrigation than there is water to irrigate it. There is need, therefore, for wise selection in choosing the lands to be irrigated. It is essential that only the better lands be chosen for irrigation even though the initial cost for supplying water to these lands might be somewhat greater than if applied to lands of poorer quality and less suitable for irrigation. It is essential that a good basic soil survey be made on lands to be brought under irrigation and their suitability for irrigation determined prior to the development of water supplies.

Soil surveys of all the major farming areas of the West should be available.—The soil survey gives basic information on the soil charac-

teristics and makes it possible to adapt the findings of research to the various lands of the West. Similar soils under similar climatic conditions should respond similarly to like treatment. It is, therefore, most necessary that the rate of obtaining basic soil information be speeded up. There is not a single State in the West where an increase in obtaining basic soil information is not drastically needed.

Utilization of ground waters

Ground-water resources are used extensively in some irrigated areas of the West and in many irrigated areas there has been excessive overdraft of ground-water and great economic loss to the area. In other areas, the ground-water resources have been largely neglected. In some of these areas, the natural ground-water reservoirs are not utilized, although considerable amounts of money have been expended to provide storage in surface reservoirs. In some of these specific areas there are serious drainage problems. The utilization of ground water for irrigation would do much to provide better seasonable distribution of water supplies, would make additional water available through exhanges for additional land, or lands in need of supplemental water, and would materially lessen the drainage problem.

Research is essential to determine the feasibility of pumping, the extent of the ground-water resources, and the effectiveness of pumping on the control of the water table. This research should include the recharging of ground water from areas where the ground water has been overdeveloped. There is no question but that the lack of adequate research is the primary reason for the overdevelopment of many of the ground-water areas and the underdevelopment of other ground-water areas. Many problems need careful study before general recommendations are possible. These include—

1. Feasibility of pumping in specific areas as influenced by—
   (*a*) Occurrence, permeability, and extent of ground-water aquifers.
   (*b*) Depth of water table and depth of aquifers.
   (*c*) Effect of pumping on control of ground-water drainage.
   (*d*) Quality of ground waters.
2. Effect of pumping on existing water rights.
3. Basic research on hydraulics of wells including the economics of applying sound basic principles to the development of ground-water supplies.
4. Methods of increasing permeability and infiltration of water into the soil and methods of recharging underground reservoirs.

Conveyance of water

The problem of water conveyance is one that is common to all of the 17 Western States. Competition for water continues to increase, consequently there is a growing pressure to develop new water and to increase the efficiency of the use of existing water supplies. The cost of developing many new water supplies often exceeds the cost of saving water that has already been developed. The Bureau of Reclamation states:

> Records from 46 operation projects of the Bureau of Reclamation reveal that of the 15,650,000 acre-feet of water supplied by irrigation in 1949, approximately 3,900,000 acre-feet, or 25 percent, was lost through seepage in canals and laterals. From these same records, the average annual water delivery to the farmer was 3½ acre-feet. On this basis, the 3,900,000 acre-feet loss would be more than enough to irrigate an additional 1,000,000 acres.

If the loss on lands other than those served by the Bureau of Reclamation can be considered to be of a like proportion, it is readily seen that total losses reach staggering proportions. Then, too, large acreages of lands are damaged seriously by seepage waters. Prevention of these losses would do much toward solution of drainage problems in many areas. Additional and continued research is needed on basic canal lining studies to develop new methods and materials for conveyance of irrigation water.

Dry land

The production of crops in the dry-land areas of the 17 Western States represents a major industry and is vitally important to the economy of these States and the Nation as a whole. While the magnitude of most crop yields is not as phenomenal nor is the yielding potential as large as it is in the adjacent irrigated areas, there is a wide expanse of nonirrigated land in 17 Western States on which soil and water research has tremendous opportunity of greatly increasing crop production. Because of the great diversity of climate, elevation, and parent materials, the soils of the dry-land areas of the West vary widely in their inherent properties and in their potential producing capacity. In order to attack effectively and properly the soil and water problems of these areas, it would be necessary to establish field experiments on many different soil areas and under a number of different climatic conditions in the central and western parts of the region.

Although the agricultural problems for the various soils and climatic conditions differ markedly in their over-all solution, there are problems of specific nature which will find application in many of the areas. Generally speaking, the major problems of the dry-land area can be broken down into a group of specific problems into a given pattern for any given area. The primary problems of the dry-land regions of the West are as follows:

Developing means of supplying organic matter.—The farming practices in the West have reduced the natural productivity of many soils where plant nutrients and soil physical conditions, rather than climate, are limiting factors in crop production. The original organic-matter content of many of the soils in the West has declined very much in a relatively short period of time. Several of the dry-land stations have shown from 25- to 50-percent decline in total organic-matter content of the top 6 inches of soil in a period of some 30 to 40 years. The effect of this marked decline of organic-matter level on future crop production and soil productivity, together with methods of maintaining or increasing present levels of the organic matter in these soils, is a problem which needs considerable study and attention in the future. In some areas it has been indicated that along with the decline in organic-matter levels, crop production has been lowered on many soils. Soil erodibility is increasing, and soil permeability has decreased. The true significance of this organic-matter decline should be investigated and the desired level of organic matter in the various soils of the West and ways of maintaining it must be found.

Fertilizer needs of major soil types.—Very scattered and inconclusive observations have shown that farmers in certain parts of the West can expect more immediate returns from fertilizer application than from most any other practice presently known. Detailed studies are

critically needed to determine what fertilizers to use, rates, times, and methods of application best suited to the dry-land conditions of the West. Nitrogen and phosphorus are probably the two principal elements needed. This is particularly true on the lighter and more sandy soils of the West and where the rainfall is higher.

More effective methods of controlling soil erosion.—Wind and water erosion are common in many areas of the West. We all remember the Dust Bowl days of the thirties and the detrimental effects it had on productivity of the land and the people living in the area.

This is only one of the effects of erosion. Water erosion is equally severe in certain parts of the southern Great Plains area, especially Oklahoma and Texas. Wind erosion needs to be studied from the standpoint of the nature of the losses that occur and methods of combating them. The same is true for water erosion. Research on means of controlling both wind and water erosion will involve tillage practices, cropping systems, mechanical restraints, such as contour farming, terracing, and strip cropping.

Use and conservation of soil moisture.—Since moisture is often the primary limiting factor in crop production in many of the dry-land areas of the West, detailed studies from the standpoint of determining more efficient methods of getting water into the soil, reducing loss in storage, and more timely and efficient use of moisture by the crops are needed. This is probably the most important single problem of the dry lands of the West. In many cases, it is difficult to separate one major problem from another. For example, past results have shown without question that keeping the organic matter of the soils at optimum level is closely allied to the infiltration capacity of soils for water, and water-holding capacity, thus reducing water runoff from soils. In many parts of the West, it is estimated that evaporation accounts for the loss of from 60 to 70 percent of the total rainfall. There is an urgent need for research on use and conservation of soil moisture. This will involve research on cropping systems, tillage practices, and the many other factors that tend to conserve water and utilize it at the most opportune time.

Special problems in isolated areas of the West.—In various areas of the West there are special problems in dry-land agriculture which need specific study in certain regions. These include such problems as the development of hardpans or compacted zones in the soil, the farming of excessively sandy soils and the presence in some soils of heavy clay layers at lower depths with sandy soils on the surface. In the latter case, it may be possible through research to develop means of deep plowing, thus bringing the heavier clay layers to the surface and improving the water-storage capacity and general productivity of the area. Such specific problems are found in practically every State of the West on limited acreages. Research is urgently needed on these problems even though they are not large in extent for they are important to isolated areas and to the region as a whole.

The need for a regional soil and water laboratory

At present there are many small State and Federal laboratories in the West. These small laboratories, though effective in their limited fields, fail to provide adequate facilities and personnel to attack many of the more difficult regional problems. which presently exist in the West. Some of the problems which require a regional laboratory

for a sound attack are such things as a need for basic research on the effect of chemical and physical properties of the soil on infiltration, permeability, water storage, nutrient availability both with respect to the major and minor elements and the effect of climatic variables on the levels of nutrients required for maximum production. Take, for example, the problem of nutrient availability. There is at the present time for most of the Western States no chemical method known which gives a satisfactory evaluation of the plant nutrient needs for western soils.This is in sharp contrast to the Midwest where suitable methods have been developed and are extensively used in State, county, and commercial laboratories scattered throughout the States and, in some cases, in practically every county, solely for the purpose of analyzing the farmer's soil and telling him how much fertilizer he needs to apply for maximum production.

Of course, basic to the setting up of a laboratory for soil analysis is the fact that one must be able to analyze the soil with some degree of precision, and the results obtained must be capable of interpretation over a broad range. In the West, with high amounts of salts present in the soils, it has been impossible to use methods prevalent in the Midwest and East. There is little doubt, however, if sufficient funds were spent for research in the endeavor to devise methods of analyzing our western soils that a satisfactory procedure could be worked out. If such procedures were available, laboratories could analyze the soil and determine the fertilizer needs which would result in a great saving in dollars spent for fertilizer and would permit increased efficiency in fertilizer use as well as greatly increasing crop production and profit to the farmer.

Another pressing question concerns the amount of water needed by various crops under certain conditions. At present, water needs for crops are determined through expensive and laborious field trials. If laboratory and greenhouse facilities were available, it would be possible to determine precisely under controlled conditions many of the water needs, methods of irrigation, and cultural practices that are now determined in the field. After the problem is initially investigated, final field testing could be made with relatively simple and inexpensive experiments.

A great need exists for a regional laboratory where soil and plant samples from sites of field investigations, new irrigation projects, and special problem areas may be scrutinized by means of rapid, routine procedures.

In our age of science, more precise equipment and better means of chemical and physical investigations are being developed daily. Usually this involves expensive and complicated apparatus. Such apparatus cannot be placed at every location, but one piece might well be placed in a regional laboratory where it could meet the requirements of the West as a whole. Great savings in expense would result if the special apparatus could be concentrated at one location, difficult soil and plant problems could be attacked, and new progress made that would result in increased productivity of our lands.

As with specialized equipment, brains and know-how of scientists also could be better utilized if concentrated in a regional laboratory. Science has become very complex, and it is no longer within the capabilities of one scientist to adequately attack our many problems. Specialization is required, and specialization is expensive if the work

must be duplicated at many locations. The committee believes that a regional laboratory could efficiently provide for such specialization, at a minimum cost, which would permit more rapid solution of our difficult soil and water problems. More detailed information on the need for the laboratory is given in the Appendix.

Soil- and water-research needs on new lands to be irrigated

The report on soil- and water-research needs of the 17 Western States as summarized above, is for land which is already under cultivation—either irrigated or dry land. As we all recognize, the Bureau of Reclamation is building dams, canals, and irrigation structures which will continue to bring more land under irrigation. The committee feels it is of interest to the association to know something of these plans and the thinking of the officials of the Bureau of Reclamation with respect to the need for soil and water research on these lands.

Early in the spring of 1951 the regional offices of the Bureau of Reclamation prepared tables for each project, showing (1) the area for which water will be furnished with respect to new acreages and to supplemental acreage; (2) the probable date of the various stages of completion of the projects; and (3) the major agricultural problems likely to be encountered on the project. Included in this was their estimation of what was needed in the way of agricultural research.

For most projects nearly all of the various regions of the Bureau of Reclamation have indicated the need for soil and water research on problems such as fertility requirements; irrigation requirements in relation to fertility level and type of crop, cultural practices; crop-adaptation practices, irrigation practices such as length of run, size of head, and the effect of slope; soil permeability and drainage studies; and alkali and salinity problems. Many other soil and water problems are listed which are common to most irrigated areas.

In studying over this report, it is obvious in nearly every area that the Bureau of Reclamation feels there is an urgent need for increasing the soil and water research on lands which are to be brought under irrigation.

"Pilot farms" are essential in soil and water research

If we make a close examination of the farmer's management problems, we find he is operating one of the most complex of all business enterprises. The total operation is made up of scores of individual factors, each having a relationship to, and interaction on, all of the others. His problem of management is to fit the numerous individual production factors together in a way to maximize the return for his labor, land, and materials on a sustained basis.

The farmer must integrate the individual practices of crop and livestock production, properly geared to soils on his farm, with the agricultural economy of his area, his own financial, managerial, and labor resources, and his long-time operational goal. He must think about crop rotations, made up of the best varieties, land drainage, liming, use of fertilizers, tillage for weed control and water conservation, erosion-control devices, and scores more. They all must be fitted together.

Farmers are given a vast amount of specialized help. In fact, the "specialist" approach to agriculture has become conventional. The farmer is given specialized information in agronomy, horticulture, pathology, entomology, animal husbandry, dairy husbandry, soil

management, and many other fields. He has a whole army of specialists to serve him, but he is left mainly to his own devices for working out the specialized job of fitting together their varied recommendations into a workable system for his own farm. He is handed the many pieces to the jigsaw puzzle, but very few clues for putting it together. Actually, many of the pieces handed him cannot possibly be fitted together without some alteration.

A close examination of our many educational devices in agriculture reveals one common weakness: the "specialized" or "single factor" approach. When a new product or process is developed in commercial industry, it goes through a period of pilot-plant study before the final workable process or equipment is developed from original principles and procedures. This is true no matter how sound and workable the new development is thought to be.

In the field of agriculture, the entire responsibility and expense for the pilot-farm stage has been thrown upon the individual farmer. The farmer is given only the original patent, as it were, and he must adjust the new principles to his own farm and operations. Consequently, new discoveries often sit on the shelves for months or even years until some enterprising farmer with the imagination, and enough capital to take the risk, tries them out in an operating farm system. Such a farmer gets the "bugs" out of the new practice, and fits it into a farming system. Through natural observation this may pass around to other farms, but the rate of spread is too slow and often the cost has been too great to the farmer who worked it out. In terms of national needs, this system is not effective.

The Alabama Experiment Station has set up a few farms where the findings from research at the station are worked into a balanced farm plan.

It is the belief of the committee that the pilot farms should be operated under a contractual arrangement with the State agricultural experiment stations. Under such direction they would have at their fingertips authorities in practically every field of agriculture. This should make it easy for the integration of the various new, improved soil and water practices into an over-all, integrated farm system. The exact number of pilot-research farms in a given State, of course, would vary with the climatic conditions, with the soils, types of farming, and other factors.

As has been pointed out above, science has become more specialized. The solution of many of the problems has been as a result of this specialization, and the solution to many of our more difficult problems are yet to be solved and will be as a result of highly specialized research. Modern science must be specialized. At the same time, however, we must combine the findings of this specialized research and integrate these into new production practices. It is not enough to isolate a given problem from the soil, crop, and climatic environment by taking it to the laboratory for study. Scientists need to study the interplay of the various factors involved, working with the problem of farm management in its environment. Our whole soil- and water-research program needs to be keyed to the principle of applying our new technology as an integrated program rather than isolated segments. It is essential that pilot farms be a part of a sound over-all soil- and water-research program for the West.

A comprehensive program of watershed-management (soil and water) research on noncultivated lands of the 17 Western States

The principal objective of the watershed-management research on noncultivated lands is the discovery of methods for handling forest and range lands which will produce maximum yields of usable water, minimum yield of sediment, and maximum returns from the other resources. This means that, in considering a program of watershed research, we must also consider the other uses to which the land may be put. Timber production, forage production, recreation, fish and wildlife resources are all intimately interwoven in the over-all watershed pattern. Whatever our watershed program may be, it must be worked out in terms of the economic use of timber and forage and accessory values.

We need to determine what is wise and adequate watershed management on nonagricultural lands. Erosion on these lands is reducing their ability to contribute to the economic welfare of the various river basins. Sedimentation from eroding watersheds is decreasing the value of irrigation improvements and increasing the cost of maintenance and replacement.

The object of watershed research should be to bring about a workable optimum—the reduction of erosion and sedimentation to the economic minimum. The effects of geologic, natural, or unpreventable erosion need to be clearly separated from those induced by preventable causes or that can be controlled by manipulations within the general scope of land-management programs.

This phase of research involving the isolation of cause and effect for erosion and sedimentation is an important part, but only a part of the over-all watershed problem. It is the first step in improved watershed management. But without research in the biological field—particularly forest and range management—there is no base on which to build a sound watershed-management program. Nor should the engineering phase be neglected.

In the past, forest- and range-management practices have been directed toward producing timber, food, and fiber. Few of them have taken into account the fact that forest and range uses can be an aid or a deterrent to water flow or to the production of sedimentation. Likewise, engineering practices have been directed toward impounding water (and silt) with little or no attention to control at the source; yet, soil and water are the basic life-supporting elements without which natural and developed production could not exist.

Watershed management is particularly important in the 17 Western States where irrigation and power developments are being planned and constructed on the basis of maximum use of the water resource. If watershed-management is to keep pace, a great deal of research is needed and needed now.

BUDGET REQUIREMENTS

The committee has studied the budget estimates in considerable detail. In studying the various problems for the States, the committee has been particularly impressed with the fact that there are many problems that are common to many and, in some cases, to all States and that such problems should be studied on a coordinated regional basis. Some of these problems are as follows:

1. Development of improved soil tests.
2. Water requirements and irrigation practice.
3. Procedures for the reclamation of saline and alkali soils.
4. Fertility requirements.
5. The determination of the suitability of soils for irrigation.
6. General practices for increasing productivity of an area and the integration of these into farming systems.
7. Drainage requirements.
8. Basic studies on soil and water.

In such studies all unnecessary duplication should be eliminated by joint planning. Many of these problems need a concentrated attack. It is the feeling of the committee that such objectives can best be met through the regional approach to the many soil and water problems involved in the Western States. It appears that a regional soil and water laboratory is a necessity if such an approach is to be realistically met. In recent years there has been evidence that big dividends are being received from joint attacks on problems. The committee recognizes, however, that in regional studies the basic problems may be solved, but that the solution of these problems must be reduced to local-site conditions before they can be applied over the entire West. It is the firm belief, however, that the basic problems can best be solved through a regional approach by the research workers of the West. Pilot farms must be available to reduce these basic plannings into farm practices.

After careful consideration the committee believes that the following budget would provide sufficient funds to initially get a soil and water program underway.

	Continuing	Nonrecurring
	Thousands	*Thousands*
Regional soil- and water-research laboratory	$600	$1,300
Research for cultivated lands and lands to be brought under irrigation by Bureau of Reclamation	6,000	
Pilot-farm research	680	2,720
Research on noncultivated lands	1,000	3,000
Total	8,280	7,020

In arriving at this figure, it was the feeling that the total amount suggested for the regional soil- and water-research laboratory is a necessity. This is also the thinking with respect to the pilot-farm research. Sums of money indicated for the cultivated and noncultivated lands are somewhat lower than the total for the individual items, but it is thought these budgets would be sufficient to get work under way. It is the belief of the committee that the required funds indicated should be earmarked by Congress for soil and water research in the West. While these funds are a necessity if the soil and water problems are to be solved, they should not be made available at the expense of other research which is now being conducted by the Department of Agriculture. It is the thinking of this committee that further study should be made by the National Reclamation Association on the needs and the results which will be obtained from the research moneys that might be appropriated for this work. If, from time to time, changes are necessary, the Association will be interested in making these facts known to the public.

Considerable thought has been given as to how these funds might be expended. In summary, however, it can be stated that the committee feels if funds can be secured for soil and water research as indicated, the program should be under the direction and control of a regional director. In this particular instance, a region could, and probably would, embrace the 17 Western States. The director should have administrative responsibilities with an office conveniently located within the region and should have the responsibility and authority to coordinate all Federal soil and water research in his region. Such coordination should be at the field level and may largely be accomplished by contract relationship between the director and various agencies outlined in the body of this report.

The funds should be appropriated to the Agricultural Research Administration of the United States Department of Agriculture. The director who has charge of these funds would be responsible to the Agricultural Research Administrator. The director would have a small staff to manage and coordinate the program, but he and his staff would not be actively engaged in the research itself. Upon the recommendation of the director, the Research Administrator would have authority to allot money to Federal research agencies in the Department of Agriculture and to contract with State agricultural experiment stations who, in turn, would do the needed research.

The committee has given this careful thought and believes when we start talking about further appropriations for further bureaucratic activity we should accompany it with thorough consideration as to the efficiency of the spending agencies. The committee believes that it is essential to have one director to work with the various research agencies and that new agencies should not be created but, on the contrary, the efficiency of the agencies already established should be promoted. The committee further feels that if the funds suggested can be secured for soil and water research as indicated in the report, that, in the appropriation of these funds to the Secretary of Agriculture, it should be so stated that at least 50 percent of these funds will be contracted with now existing non-Federal agencies who are conducting research in the West. This would mean the State agricultural experiment stations in the individual States. Most of these experiment stations have facilities and personnel which could utilize to good advantage an increase in funds. The new personnel which would be required would be those primarily in the lower professional grade, or nonprofessional help.

It is noted that there are no funds set up for capital investments under the headings of estimates by States for cultivated lands and research on lands to be brought under irrigation by the Bureau of Reclamation. The reason for this is that it is felt there are sufficient facilities now available that additional expenditures will not be needed in capital outlay. To be sure, it may be necessary to purchase certain equipment and facilities, but it is felt these can be purchased primarily out of the first year's funds and that the others then will be available for continuation of the work. It is only in the case of the regional soil and water laboratory, pilot farms, and noncultivated areas that it is felt there will be any sizable expenditures for office buildings, laboratories, etc.

The total cash receipts by farmers in the 17 Western States in 1949 was some $10,590,000,000. The committee suggests a reoccurring

budget of $8,280,000 for soil and water research. This amounts to about only 80 cents per thousand dollars of the farmers' cash receipts in 1949. The results of soil and water research indicate a possibility of increasing production 50 to 100 percent. Even a 1-percent increase would mean an annual addition of some $100,000,000. This is over 10 times the amount set forth as a minimum required expansion for soil and water research. Certainly, this is a very conservative recommendation in terms of soil and water research, especially in relation to the possibilities of increasing the total farm output as indicated in various parts of this report.

RESEARCH ON SOIL AND WATER MUST BE INCREASED IMMEDIATELY

Nearly every irrigation project in the West has its soil and water problems—those problems can only be solved through research. It would be difficult to find a single project where lands are not going out of production due to a lack of research knowledge or its application on irrigation projects. There are other areas where land may not be going out of production, but on which the productivity has decreased much below economic operation.

The Riverton project in Wyoming is given as an example of such a project. This project is neither the worst nor the best insofar as being plagued with soil and water problems. It is noticed here that nearly half of the land is either out of production or is gradually going out of production and below an economic level needed for irrigation agriculture. It is pointed out that some $18,000,000 has already been authorized for expenditure by the Federal Government for this project. In addition to this, farmers and businessmen have expended millions upon millions endeavoring to develop this land into a permanent and profitable irrigated region. Production is declining rapidly and the whole project is threatened, yet little or no research is being done.

Certainly, it would be sheer folly for the Government not to invest whatever money is needed in soil and water research in order to solve the many problems which are plaguing this area and which are causing the decline of productivity. The solution of the soil and water problems can effectively stabilize this project, bring it back to productivity, remove the salinity and alkali from the area and establish a permanent and profitable irrigation agriculture. As indicated above, this is just one example of the many projects which are similar to it.

Need for increased production in the future

There is not one of us who has not read in popular magazines, daily papers, or even books, articles on the future needs for food and fiber in this country. Some of these articles would lead us to believe that it will not be possible for this Nation to provide sufficient amounts of food and fiber to feed and clothe the people of this country, say 50 to 100 years from now. Conservative estimates have been made that at least another 100,000,000 acres of land will have to be brought under production to feed and clothe the increased population. Certainly we do not have this much land available to bring under cultivation. An optimistic guess is that another 15,000,000 acres of land can be brought under cultivation through irrigation. The primary way in which the production can be forthcoming is through an increase of productivity of lands which are already under cultivation. This

will be brought about only through an increase in research. Soil and water research in the West can and will play an important part in increasing the productivity of the areas and in helping provide food and fiber which will be needed for our future population.

Lands going out of production with salt and alkali

As was pointed out earlier, from 1929 to 1939, there were over 1,000,000 acres of irrigated land in the West which were abandoned due to excessive salts and alkali. There were millions of other acres on which the productivity of the land was decreased, say some 15 to 25 percent in total yields. A continuing prosperity of the entire West depends upon its irrigated lands. Steps must be taken immediately to provide the basic soil and water research necessary to reclaim the lands that are now going out of production and prevent further lands from decreasing in productivity. In addition to this, pilot farms must be made available in order that these basic findings can be reduced to practice and adopted on the many irrigation farms.

Only the best lands should be selected for new irrigation projects

The limited water supply in the West, combined with the increase in cost of getting the remaining water on the land, is a major obstacle in expanding irrigation agriculture. In the West there is considerably more land with soils suitable for irrigation than there is water with which to irrigate it. It is essential, therefore, that only the better lands be chosen for irrigation even though the initial cost for supplying water to these lands might be somewhat greater than to supply it to the lands of poor quality and less suitable for irrigation. There is an urgent need for research to be certain that the best lands are put under irrigation and that all such lands can be brought to a profitable production and can remain stable throughout the future generations.

Low yields on many of the irrigation projects can and must be raised

One can look at the yields on most any irrigation project in the Western States, or as far as that goes, on most any dry-land area in the 17 Western States and find farmers that are getting relatively good yields along with a large number of farmers whose yields are submarginal or only marginal. The question immediately arises as to whether or not the marginal and submarginal farms could produce as well as the better farms in the area. In some cases the answers are available and it can be said that the poor farms with proper management could produce as well. However, in a large number of cases, it is impossible to answer this problem.

At Umatilla, Oreg., the project average yield of corn was some 34 bushels per acre in 1939. In 1950 the farmers were using enough research results to raise the project average yield of corn to 58 bushels per acre, while at the same time the experiment station was getting up to 200 bushels per acre.

Other examples are the Scotts Bluff project in which almost all of the irrigated districts surrounding this experiment station failed to get within 50 percent of the yields of the experiment station. In fact, nearly all of the yields of the major crops on this station exceeded by 100 percent the average for the surrounding irrigation projects.

Another example is the Huntley, Mont., Experiment Station. Here records are available for some 22 years of a rotation on the Huntley

Experiment Station. This average is compared with the yields of the Huntley irrigation project. In most cases the yields on this station are at least 100 percent higher than those of the major crops of the project. This shows that the climate and soil conditions are such in this area that tremendous increases could be made to the over-all production of the project. It does not mean, however, that one could take the results from this station immediately and apply them to the entire project. There are variations in climate, soil structure, soil physical and chemical conditions, and soil type.

The results of the research conducted on the Huntley station must be reduced to farmer conditions. This requires continuing research and the application of it through a pilot farm to an integrated farm system that can be applied to the farms of the area. It does, however, point out the tremendous possibility of increasing production of many of our irrigated areas. It is essential that all of our irrigated and non-irrigated areas of the West have their soil and water problems solved through research, and the productivity of the entire area increased.

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